AN 2119
APPLICATION NOTE

Getting Started with uClinux for STR71x

INTRODUCTION

UClinux is a derivative of the Linux 2.0 kernel intended for use as an operating system in microcontroller applications.The tools, files and procedures described in this document will help you get started using uClinux on any of the **STR71x**, ARM7TDMI core-based microcontrollers.

Necessary software and hardware tools

The **uClinux software kit** is designed for use with the **STR710 Evaluation Board** (STR710-EVAL).

Note: Building the uClinux kernel requires a host PC running the Linux OS.

The **uClinux software kit** includes the uClinux operating system (OS) and the bootloader required for booting up the board and loading uClinux. The OS is ported from the standard distribution *uClinux-dist-20040408*, which implements the Linux kernel *2.4.24-uc0*. The software tools can be downloaded at www.uclinux.org, or using the following direct links:

- **ARM-ELF toolchain** *(arm-elf-tools-20030314)* **–** *www.uclinux.org/pub/uClinux/arm-elf-tools/arm-elf-tools-20030314.sh*
- **uClinux full distribution** *(uClinux-dist-20040408)* **–** *www.uclinux.org/pub/uClinux/dist/uClinux-dist-20040408.tar.gz*

To compile an application independently from a uClinux image (*Section 5.2*) you will also need the **make JFFS2 special utility**. You can download it at: sources-redhat.oc1.mirrors.redwire.net/jffs2/mkfs.jffs2

The **STR710 Evaluation Board** has been designed by STMicroelectronics for evaluation and application development for the STR71x ARM7TDMI core-based devices and includes an STR710F processor. The STR710F device can be programmed using the *RealView ICE-ME JTAG run control device*, or other programming tools for ARM7TDMI core-based microcontrollers.

Note: Programming the STR710F on the evaluation board requires the use of an in-circuit programmer/in-circuit emulator with JTAG interface and the appropriate programming software. You can find more information about development tools for STR7 at www.st.com/mcu.

Getting started

To help you get started using uClinux in your STR71x application, this document provides procedures to help you:

- *Install the tools*
- *Build the uClinux kernel*
- *Use the bootloader*
- *Use uClinux*
- *Add your application for debugging*

If you want to upload the uClinux image (zimage.bin) provided in the binary files of the uClinux distribution to an STR71x device, refer to the section *Use the bootloader*.

This distribution of uClinux already contains a sample application for read/write of I2C EEPROM for demonstration purposes. However, if you already have an application that you want to try with uClinux, refer to the section *Add your application for debugging*.

For more information, you can refer to *Additional references*.

1 Install the tools

This section explains how to install the software tools that are required to build the uClinux image on a host PC running Linux. To correctly install the tools you must *Install the arm-elf toolchain*, *Install the uClinux distribution* and *Patch the uClinux distribution for STR710*.

1.1 Install the arm-elf toolchain

To install the arm-elf toolchain,

1. Login as “root.”
2. From the directory that contains the arm-elf toolchain, run:

```
sh arm-elf-tools-20030314.sh
```

The rest of the installation is automatic. When this installation is complete, continue by installing the uClinux distribution.

1.2 Install the uClinux distribution

To install the uClinux distribution on your PC:

1. Login as the user that you are going to use for development.
2. Copy the file **uClinux-dist-20040408.tar.gz** to the user's home directory, or wherever you want to work from.
3. Go to the directory that you downloaded the file to, and run:

```
tar xzvf uClinux-dist-20040408.tar.gz
```

The uClinux file structure will be extracted to the chosen directory. A sub-directory is created called **uClinux-dist**, which contains the whole distribution.

When this is complete, continue by patching the uClinux distribution for use with STR710.

1.3 Patch the uClinux distribution for STR710

1. Copy the **uClinux-dist-20040408-str710-patch.tar.gz** file from the uClinux package for STR7 to the **uClinux-dist** directory and then run:

```
tar xzvf uClinux-dist-20040408-str710-patch.tar.gz
```

The **uClinux-dist-20040408-str710-patch** file is output in the chosen directory. This file is the STR710 porting patch file for uClinux-dist-20040408 distribution, implementing the Linux kernel 2.4.24-uc0.

2. Now, run:

```
cd uClinux-dist
```

```
patch -p1 < uClinux-dist-20040408-str710-patch
```

The ST directory and its sub-directory STR710 are added to the "vendors" directory in the **uClinux-dist** directory. Once this has been done, you are ready to *Build the uClinux kernel*.

2 Build the uClinux kernel

Once you have installed the tools, you can configure and build the kernel into a binary file. You don't need to be logged on as root from this point on.

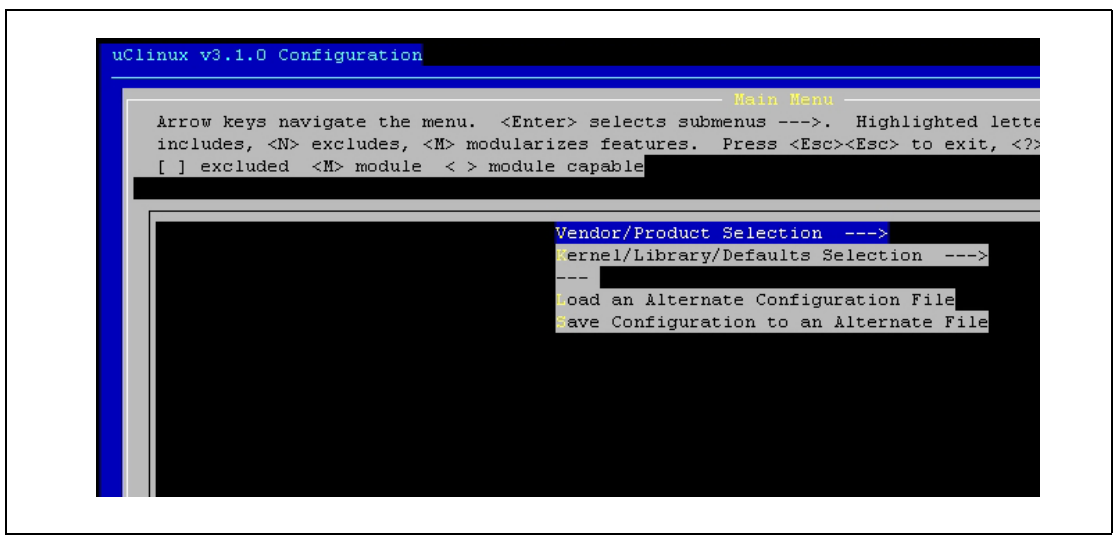
2.1 Configure the uClinux kernel

1 To configure the kernel, go to the **uClinux-dist** directory and run the configuration utility:

```
make menuconfig
```

This will run the configuration program that is shown in *Figure 1*, below.

Figure 1: uClinux configuration main menu


uClinux v3.1.0 Configuration
Main Menu
Arrow keys navigate the menu. <Enter> selects submenus --->. Highlighted lette
includes, <N> excludes, <M> modularizes features. Press <Esc><Esc> to exit, <?>
[ ] excluded <M> module < > module capable
Vendor/Product Selection --->
Kernel/Library/Defaults Selection --->

Load an Alternate Configuration File
Save Configuration to an Alternate File

2 In the configuration program, select **Vendor/Product Selection**.

3 Enter your **vendor/product** combination, the **Kernel version** and the **Libc version** according to the table below:

Table 1: Vendor/product combination

Vendor / product selection	Vendor	**ST**
	ST products	**STR710**
Kernel / library /defaults selection	Kernel Version	**Linux-2.4.x**
	Libc version	**uClibc**
	Default all settings (lose changes)	**-**
	Customize kernel setting	**-**
	Customize vendor/user setting	**-**
	Update default vendor setting	**-**

4 Save this configuration by selecting ***Exit*** and choosing ***Save***.

Note: Choosing the options: ***Customize Kernel settings*** *or* ***Customize Vendor/User settings*** *will run other menus after you exit and save the menuconfig settings. For descriptions of each option, select* ***help****.*

When configuring for the first time, set the following to default: ***Default all settings (lose changes)****,* ***Customize kernel setting****,* ***Customize vendor/user setting****,* ***Update default vendor setting****.*

You can also use ***make config*** *or* ***make xconfig*** *to configure the basic kernel.*

2.2 Build the uClinux kernel

In order to correctly set up all the dependencies, when the configuration process completes:

1 First, run:

```
make dep
```

2 Once this is completed, run the following commands:

```
make lib_only
make user_only
make romfs
make romfs
make image
```

Note: You need to run ***make romfs*** *twice, because the first time* ***romfs.img*** *is generated in the* ***uClinux-dist/images*** *directory, it is only about 15K. This is not the correct size. After the first* ***make romfs****, the "init" has not been built into romfs.img. After the second* ***make romfs****, the size of romfs.img is larger than 200K. This is the correct size.*

After compiling with no errors, there should be a new binary file (***zimage.bin***), in the **uClinux-dist/images** directory. This is the uClinux binary file.

Once you have built the uClinux binary file, you need to load this file into the external Flash of the STR710F device of the STR710-EVAL using the bootloader.

3 Use the bootloader

The bootloader allows you to load the uClinux binary file (zimage.bin) to external Flash on the evaluation board. Loading the bootloader for requires the use of a programmer or in-circuit emulator with JTAG interface and the software to drive it. For this purpose, we have used the RealView Developer Kit (RVDK) for ST and the RVICE-ME JTAG run control device that is with this kit.

The following sections provide procedures for using the bootloader including how to:

- *Load the bootloader to the STR710-EVAL board*
- *Configure the host computer for serial download*
- *Configure and connect the STR710-EVAL board for serial download*
- *Serial download an image to external SRAM*
- *Program the image to external Flash*
- *Boot uClinux*

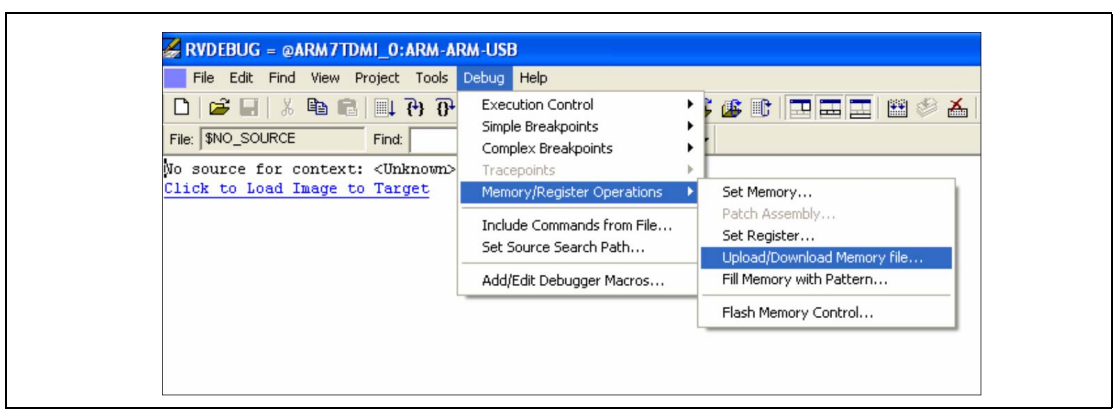
3.1 Load the bootloader to the STR710-EVAL board

The bootloader (71xboot-R10.bin) image has to be programmed in the beginning of the external Flash memory (0x60000000). It must be executed first after a power up or a reset. It allows the loading of the uClinux image (zimage.bin) into the external SRAM (0x62000000) via a serial port.

To load it using RVDK:

1. Set SW13, SW14, SW15 on the STR710-EVAL board to RAM boot mode, as shown on page 13 of the *STR710-EVAL Datasheet*.
2. Install and start RVDK.
3. Connect the RVICE-ME JTAG run control device to your PC and the **JTAG (CN9) port** on your STR710-EVAL board.
4. In RVDK, select ***Debug>Memory/Register Operations>Upload/Download Memory file…*** in the main menu.

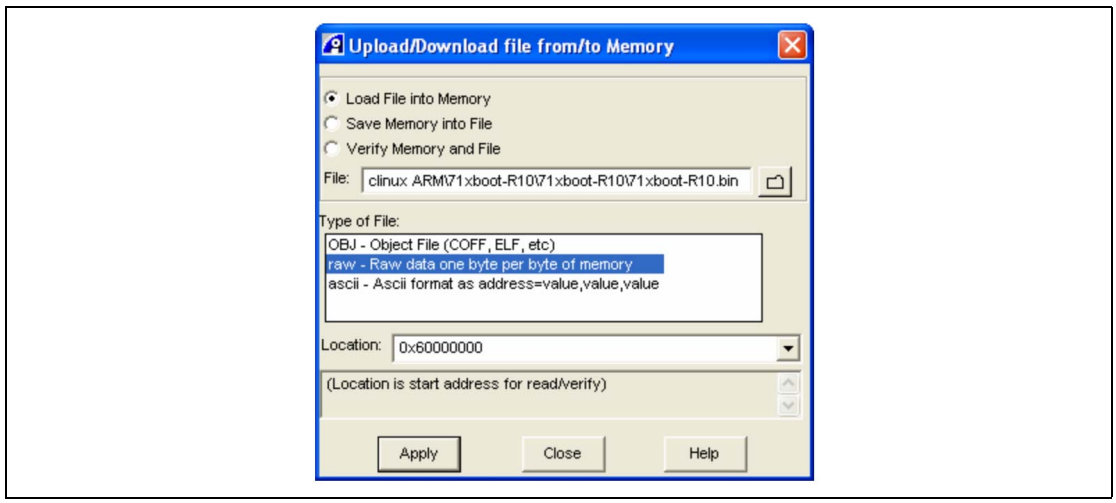
Figure 2: RVDK for ST memory operations menu



The **Upload/Download file from/to Memory** dialog box appears (see *Figure 3*).

5 Fill in the fields of the prompt window as shown in *Figure 3*. In the **File** field, make certain to enter the full pathname of the bootloader image (71xboot-R10.bin). Once you have configured all the parameters, click on ***Apply***.

Figure 3: Upload file with RVDK for ST



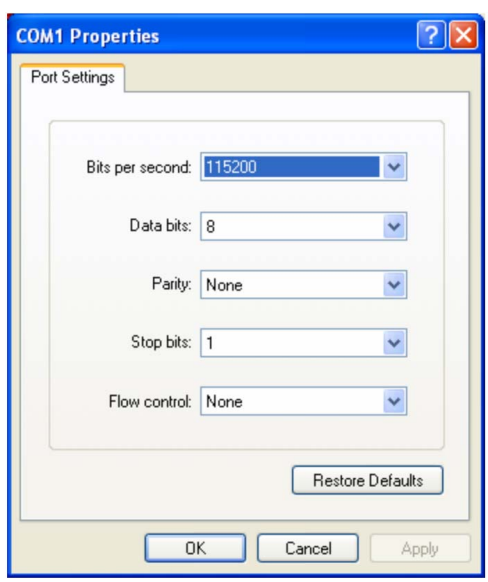
After you have loaded the bootloader image to the external flash of the STR710-EVAL board, you will have to *Configure the host computer for serial download* and *Configure and connect the STR710-EVAL board for serial download*.

3.2 Configure the host computer for serial download

The host computer must support a fully functional serial terminal, e.g. Microsoft HyperTerminal running on a Windows PC.

In Windows, launch HyperTerminal. Create a new connection and configure the port settings according to *Figure 4*:

Figure 4: COM1 properties window



3.3 Configure and connect the STR710-EVAL board for serial download

3.3.1 Configure the STR710-EVAL board

1 Check that the following option jumpers on the STR710-EVAL board are in there default positions:

Table 2: STR710-EVAL jumper configuration

Jumper	Description	Position
• **J1**	CAN link	**Fitted**
• **J3**	VBKP supply	**Fitted**
• **J4**	notJRst/notReset ink	**Not Fitted**
• **J5**	+1.8V Supply	**Fitted**

2 Check the settings of the following option switches on the STR710-EVAL board:

Table 3: STR710-EVAL switch configuration

Jumper	Description		Position
• **SW6**	I^2C EEPROM: write enabled		**1-2**
• **SW9**	RS232 source: A		**A**
• **SW13**	Boot mode 1:	Execute code from external memory	**2-3**
• **SW14**	Boot mode 0:		**2-3**
• **SW15**	Boot mode EN:		**2-3**

For more information about jumper and switch settings, refer to the *STR710-EVAL Datasheet*.

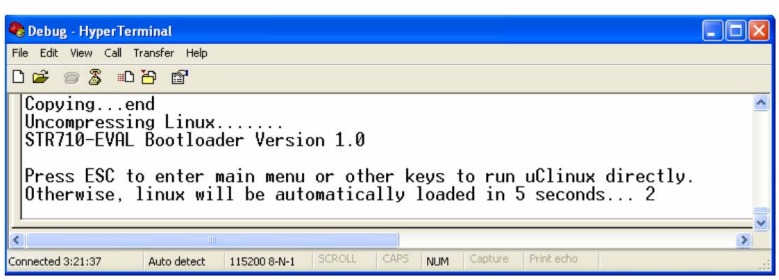
3.3.2 Connect to the STR710-EVAL board and power up

Connect the **RS232-A (CN7) port** of the STR710-EVAL and the host computer with a cross-linked serial cable.

To power up the board, connect the power adapter to the **+5V PWR (CN2) port** of the STR710-EVAL.

Upon power up, the hyperterminal displays the messages shown in *Figure 5*. These are displayed for 5 seconds. Press the **ESC** button to enter the bootloader's main menu *(shown in Figure 6)*.

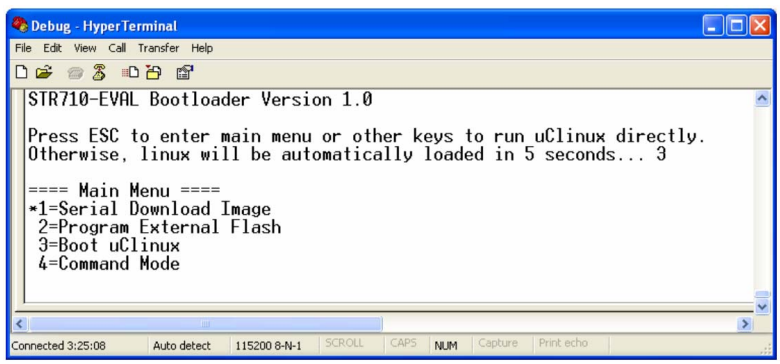
Figure 5: Hyper terminal startup messages



*Note: If **no key** is pressed in the HyperTerminal window during the 5 seconds after powering up, the bootloader waits until the end of the 5 seconds and the automatically downloads uClinux.*

*If **any key other than ESC** is pressed during this period, the bootloader will download uClinux immediately.*

Figure 6: Bootloader main menu



You are now connected to the STR710-EVAL board and the bootloader is ready to download an image using the serial port. To start downloading, go on to the section *Serial download an image to external SRAM*.

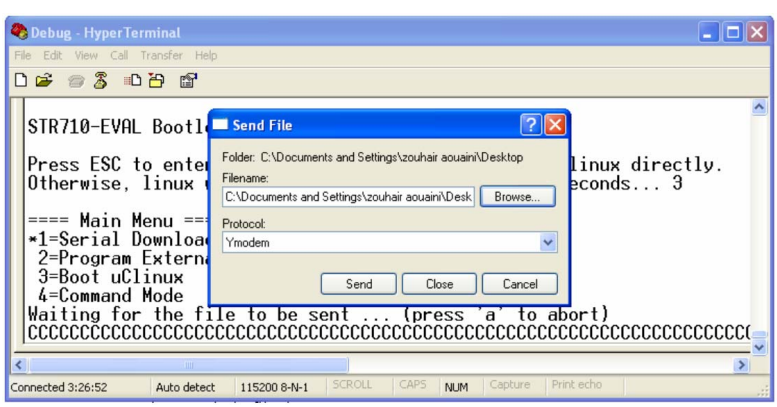
3.4 Serial download an image to external SRAM

The serial download module allows the programing of binary files to external SRAM through a serial port. Ymodem protocol is implemented for this purpose.

To download the uClinux binary file to SRAM:

1. Press **1** to select the menu item **Serial Download Image**. The bootloader waits for a file to be sent by the host computer. (You can press **A** to abort this operation.)
2. Select ***Transfer>Send File...*** from the **HyperTerminal** menu. In the pop-up dialog, select the file to be downloaded and choose **Ymodem** protocol, then press the **Send** button (*Figure 7*).

Figure 7: Serial download to SRAM



3 Download starts. The messages **Transfer Completed**, **<filename> Received** and **<number> Bytes** are printed upon completion.

Note: The default external SRAM address used to store the downloaded images is 0x62000000. The image size is automatically saved as a global variable after image transfer is completed.

The uClinux binary has been downloaded to SRAM. Go on to the next section, *Program the image to external Flash*.

3.5 Program the image to external Flash

Now, the Flash programming module is used to program the image that you have downloaded to the SRAM into the external Flash memory.

To do this:

1 Press **2** to select the menu item **Program External Flash**. The bootloader will prompt you for an offset address of the external flash to be programmed to.

2 Enter the number for the offset address (You can type **A** to cancel this operation). If the number that you enter is invalid, the bootloader will prompt you for a new entry.

The following data formats are all valid for inputting numbers:

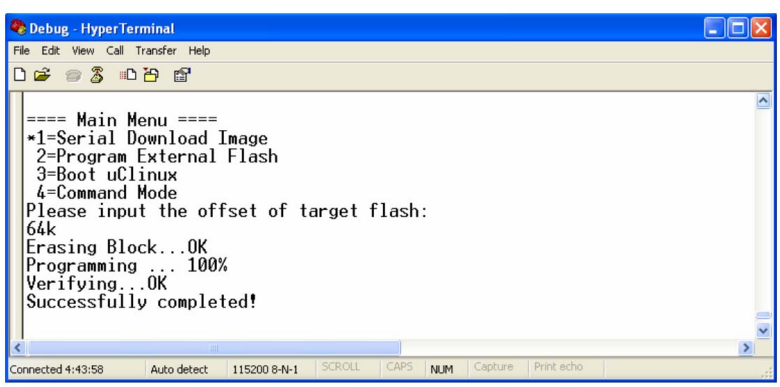
0x0	***0***	***0x312***	***6543***	***678K***	***2M***

Note: The bootloader uses 0x62000000 as the source address by default.

3 If the image size hasn't already been saved, the bootloader will prompt you to enter the size, otherwise the previously saved value is used (See note in *Section 3.4*). It you receive this prompt, enter the number corresponding to the size (You can type **A** to cancel this operation). If the number that you enter is invalid, the bootloader will prompt you for a new entry.

4 The bootloader checks the address range and performs the erase and program operations automatically (*Figure 8*).

Figure 8: Program external flash



The uClinux binary has been programmed to external Flash. Go on to the next section, *Boot uClinux*.

3.6 Boot uClinux

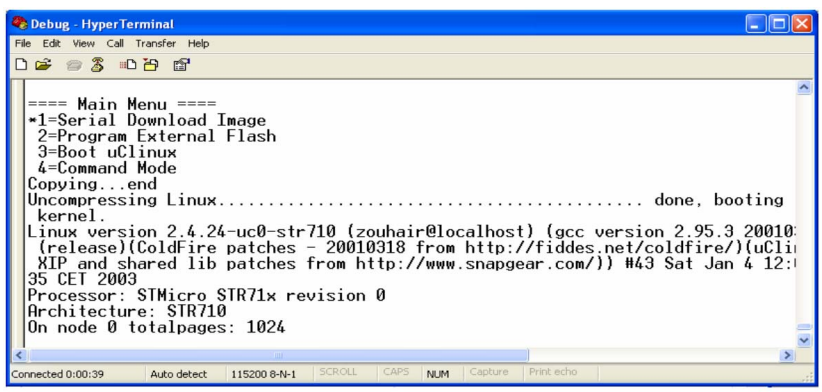
You can use the bootloader in one of two modes: **Menu mode** or **Command mode**. By default, the bootloader is in *Menu mode* when you start. The *Command mode*, on the other hand, provides more flexible command input if needed.

3.6.1 Menu mode

In Menu mode, press **3** to select the menu item **Boot uClinux**. The compressed uClinux image (zimage.bin) is copied from external Flash to external SRAM. Then, uClinux is uncompressed and starts to run (*Figure 9*).

Note: The compressed uClinux zimage is loaded from address 0x60010000 in the external Flash by default.

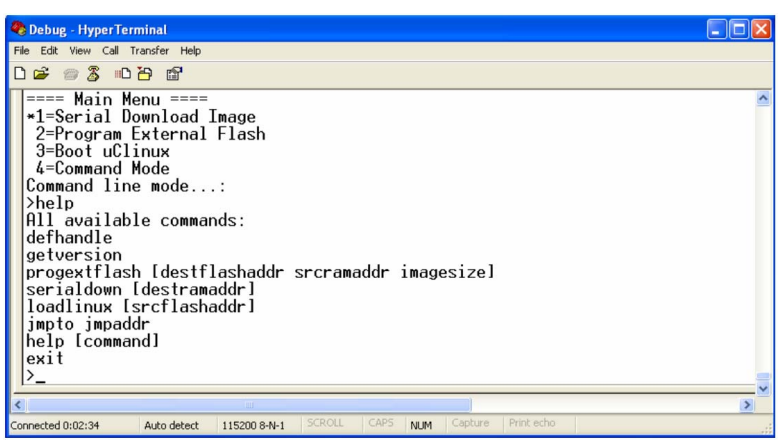
Figure 9: Boot uClinux



3.6.2 Command mode

To use Command mode, press **4** to select the menu item **Command Mode**. The command line prompt (**>**) is displayed and you can input commands. Type **`help`** for all available commands (*Figure 10*), type **`exit`** to quit command mode and return to menu mode.

Figure 10: Command mode



Frequently used commands are:

serialdown [destramaddr]

Download an image to `destramaddr` through a serial port. If `destramaddr` is not specified, 0x62000000 is used by default and it is the same as menu item 1.

progextflash [destflashaddr srcramaddr imagesize]

Program `imagesize` bytes of data stored at `srcramaddr` to `destflashaddr`. If no arguments are specified, it is the same as menu item 2.

loadlinux [srcaddr]

Load the compressed uClinux binary file, uncompress it and run the uClinux kernel. If no argument is specified, it is the same as menu item 3. If `srcaddr` is specified, it is regarded as the address of zimage stored in the external flash memory.

4 Use uClinux

UClinux is composed of:

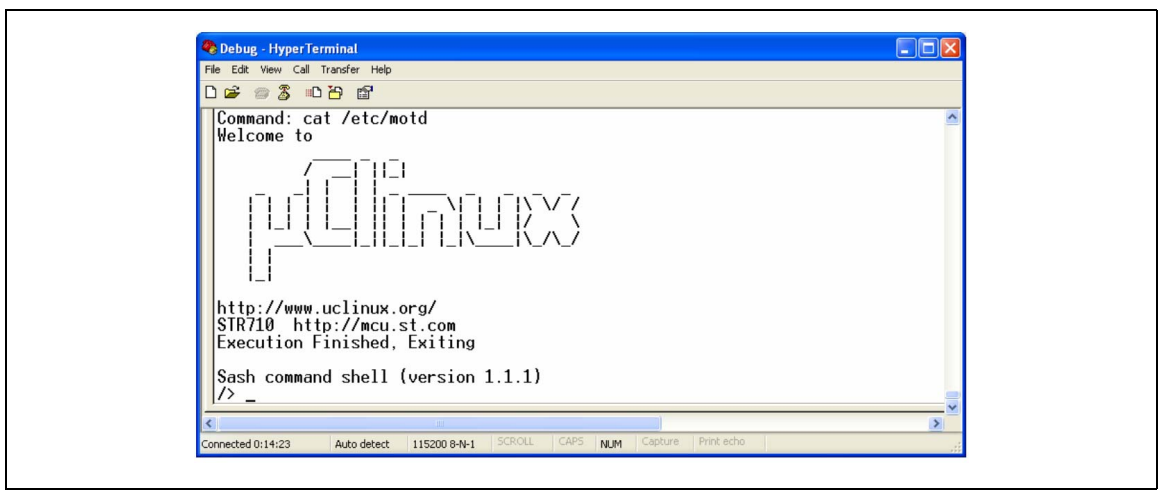
- *Sash command shell* – standard command shell supporting Linux commands
- *Memory Technology Device (MTD) subsystem* – subsystem for data management and memory driver development

If you have not modified the uClinux distribution, then it also includes a *Sample I2C EEPROM application*.

4.1 Sash command shell

The Sash command shell is automatically launched after the uClinux kernel is booted (*Figure 8*). This is a standard command shell that supports most of the Linux commands. The user can add other commands when he compiles the uClinux distribution.

Figure 11: Sash command shell



4.2 Memory Technology Device (MTD) subsystem

MTD (Memory Technology Device) is a Linux subsystem aimed at simplifying the development of hardware memory drivers and the management of data stored in memory devices, especially Flash devices. The highest layer of MTD subsystem is called "MTD user module," which provides a user-level interface to the application layer. JFFS2 (Journaling Flash File System Version 2) is used to implement the MTD user module in this project.

The 4 MB external flash memory is divided into 3 MTD partitions. Execute the command **`cat/proc/mtd`** to view the partition information:

```
mtd0offset 0x0 ~ 0x10000Store the Bootloader
mtd1offset 0x10000 ~ 0x200000Store the uClinux zimage
mtd2offset 0x200000 ~ 0x400000Used as a JFFS2 partition
```

The third partition is automatically mounted to the directory /mnt/mnt1 as a JFFS2 partition when uClinux is up. Total size of this partition is 2 MB, and user can perform file operations on this partition such as, copy (`cp`), delete (`rm`), delete directory (`rmdir`), rename (`mv`), create directory (`mkdir`), open text editor (`vi`), etc..

4.3 Sample I²C EEPROM application

The application 24CXX I²C EEPROM has been placed in JFFS2 partition. This is an application that allows you to copy the contents of the I²C EEPROM memory to a file that you name, or to write the contents of a file that you specify to the I²C EEPROM memory.

Note: More information and downloads related to this and other I²C EEPROM applications are available at http://secure.netroedge.com/~lm78/

24C08 I²C EEPROM has four blocks with a slave address of 0x54-0x57. Each block has a size of 256-bytes.

Program Usage

```
eeprom [-d dev] [-a adr] [-p pgs] [-w] [-y] [-f file]
```

dev: device, e.g. /dev/i2c0 *(default)*

adr: the EEPROM base address, e.g. 0x54 *(default)*

pgs: number of pages to read, e.g. 4 *(default)*

-w: writes to EEPROM *(Default is read)*

-y: suppresses warnings when writing *(Default is to warn)*

-f file: copies contents of the specified file to EEPROM when -w is used. Copies EEPROM to contents to the specified file if -w is not used. *(The default for read is "test only." For write, the default is all zeros).*

Examples

The following command line copies the contents of the EEPROM to the specified file. Replace `outfile` with the name of the file you want to write the EEPROM contents to, e.g. `./contents.txt`.

```
./eeprom -d /dev/i2c0 -a 0x54 -p 1 -f ./outfile
```

The following command line copies the contents of the specified file to EEPROM. Replace `infile` with the name of the file you want to write to EEPROM.

```
./eeprom -d /dev/i2c0 -a 0x54 -p 1 -w -f ./infile
```

*Note: Additional sample applications are provided with this **uClinux Package for STR710**. These are described in the readme.txt file in the User Applications directory.*

5 Add your application for debugging

Once you have started developing your own application, there are two ways of using it with uClinux. You can either *Add your application to uClinux image*, or you can *Compile your application independently of the uClinux image*. If you have already built the uClinux kernel, compiling your application independently will save you the time that it would take to rebuild the kernel with your application. In both cases the compiler used to build your application is arm-elf-gcc.

5.1 Add your application to uClinux image

For this procedure, your application should have a file that contains a main function.

```
int main(int argc, char *argv[])
{}
```

To add your application to the uClinux image:

1. Create a new makefile for your application like the one shown below:

```
EXEC = myexec
OBJS = file1.o, file2.o …
all: $(EXEC)
$(EXEC): $(OBJS)
$(CC) $(LDFLAGS) -o $@ $(OBJS) $(LDLIBS)
romfs:
$(ROMFSINST) /bin/$(EXEC)
clean:
-rm -f $(EXEC) *.elf *.gdb *.o
```

2. Create a new folder named **myprog** in **uClinux-dist/user/** directory for your application files.
3. Put your source and header files (*.c, *.h) and the makefile in the new directory **uClinux-dist/user/myprog**.
4. Now add the following line to the makefile in the directory **uClinux-dist/user**:

```
dir_y+= myprog
```

   This line tells the maker to use the directory **uClinux-dist/user/myprog**.
5. Go to the **uClinux-dist** directory and run the following commands:

```
make user_only
make romfs
make romfs
make image
```

Note: You must run the `make romfs` *command twice as indicated above.*

After you load the resulting uClinux binary file into the STR710-EVAL board (see *Section 3*), you will find your application in the **/bin** location and you can execute it by typing its name. You can add more than one application to your image file by using this same procedure.

To add your application to the uClinux configuration system:

1. Add a line to the **user/makefile**, which adds **myprog** to the list of directories to be built:

```
dir_$(CONFIG_USER_myprog_myprog)              += myprog
```

   The directory, **myprog** contains the files for your application.

2. Add a block to the **config/Configure.help** like the following:

```
CONFIG_USER_myprog_myprog
```

   The **config/Configure.help** file contains the text that is displayed on request during the distribution configuration. The text must be indented two spaces, and there must not be any empty lines. Lines should be less than 70 characters long.

3. Add a line to the **config/config.in** in the appropriate menu section (i.e. in the program group you want your application to show up in during `make menuconfig`), like the following:

```
bool 'myprog'            CONFIG_USER_myprog_myprog
```

   The repetition of `myprog` allows for directories that contain multiple executables. When all this is set up, run the standard `make menuconfig` to add your application to the uClinux image (see *Section 2.1*).

5.2 Compile your application independently of the uClinux image

You can also download your application into the STR710-EVAL board separately from the uClinux binary. To do this:

1. Add a line to the **user/makefile**, which adds **myprog** to the list of directories to be built:

```
dir_$(CONFIG_USER_myprog_myprog)              += myprog
```

   The directory, **myprog** contains the files for your application.

2. Add a block to the **config/Configure.help** like the following:

```
CONFIG_USER_myprog_myprog
```

   The **config/Configure.help** file contains the text that is displayed on request during the distribution configuration. The text must be indented two spaces, and there must not be any empty lines. Lines should be less than 70 characters long.

3. Add a line to the **config/config.in** in the appropriate menu section (i.e. in the program group that you want your application to appear in during `make menuconfig`), like the following:

```
bool 'myprog'            CONFIG_USER_myprog_myprog
```

The repetition of `myprog` allows for directories that contain multiple executables. When all this is done, run the standard `make menuconfig` (see *Section 2.1*).

4 Next, to generate your application executable file, go to the uClinux-dist directory and run:

```
make user_only
```

Once this is complete, you need to build your executable file into a JFFS2 image. JFFS2 is a log-structured file system designed for use on Flash devices in embedded systems. There is a special utility to make a JFFS2 image that you can download at:

http://sources-redhat.oc1.mirrors.redwire.net/jffs2/mkfs.jffs2

5 Copy this utility to the user directory.

6 To make the utility executable, run:

```
chmod u+x mkfs.jffs2
```

7 Create a new directory and copy the executable file of your application into this directory.

8 Run:

```
mkfs.jffs2 -r <directory> -o output-file.jffs2
```

This will generate **output-file.jffs2** in the current directory.

9 Load this file into the STR710-EVAL board (at 0x60200000 address) using the bootloader (see *Section 3.4* and *Section 3.5*). You will find your executable files in the mnt/mnt1 location.

6 Additional references

At **www.st.com/mcu**, you will find complete documentation, software downloads and user discussion groups to help answer questions and stay up to date with our latest product developments. Here, you can download the latest versions of the following additional documents:

- STR71x Microcontroller Reference Manual
- STR710-EVAL Board Datasheet

Additional information and uClinux downloads are available at www.uclinux.org.

For more details about Journaling Flash File System (JFFS) refer to:

- www.buserror.org/~ebrown/sshf2001/download/utils/mkfs.jffs2.1.html
- www1.idt.com/pcms/tempDocs/79EB438_AN_.pdf

7 Revision History

Table 4: AN2119 revision history

Date	Revision	Description
Feb 2005	1.0	Initial release

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